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Comparative Anatomical, Morphometrical, and Histological Studies of the Alimentary Canal Between the White-Eared Bulbul and the Russian Bulbul

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Phone No.: 009647734952025

DOI:10.21608/jbaar.2026.496065

Abstract

Purpose: The white-eared bulbul (*Pycnonotus leucotis*) is a common ornamental songbird in Iraq.

Objective: Yet little information is known about its digestive system. The current study aimed to explain the anatomical, morphometrical, and histological features of its elementary tract and compare them with those of the Russian bulbul (*Pycnonotus megarhynchus*). **Methods:** morphometrical measurements were taken to assess the digestive tract, including the length of the small intestine and goblet cells, then the tissues were taken for preparation using routine histological staining. **Results:** The digestive tracts of the two species differed slightly in length of small intestine and numbers of goblet cells, reflecting differences in body size and diet. The ventriculus of the white-eared bulbul was less developed compared to that of the Russian bulbul. In both species, the small intestine included three sections—duodenum, jejunum, and ileum—without clear anatomical boundaries. Histologically, the mucosa was formed from villi that were lined with simple columnar epithelium, goblet cells, and smooth muscle fibers. Goblet cells were more abundant in the Russian bulbul, with numbers increasing toward the ductal opening. No meaningful histological differences were found in the esophagus and large intestine between the two species. **Conclusions:** The two bulbul species show slight anatomical and histological variations in their digestive tracts. The higher density of goblet cells in the Russian bulbul may reflect differences in dietary adaptation.

Keywords: Esophagus; Goblet cells; Large intestine; Small intestine; Ventriculus.

Introduction:

Birds are warm-blooded vertebrates with feathers, toothless beaks, and hard-shelled eggs. There are approximately 11,000 species, classified into 44 orders. More than half of them are passerines [1]. The digestive system is essential in most animals, particularly birds, since it provides energy for everyday activities by consuming, digesting, and absorbing food [2, 3]. Birds have a thoracic cavity with no diaphragm. The bird's esophagus is a long, inflatable tube that connects the oropharynx with the

ventral portion. It is positioned on the right side of the neck, dorsally to the trachea and the thoracic inlet. The esophagus returns to the midline and extends ventrally, forming the gizzard [4]. It is worth noting that the common quail's esophagus is separated into three regions: the cervical, crop, and thoracic [5]. Granivorous birds' intestines are tubular in form and have a smaller diameter than their gizzards. The duodenum, the first section of the small intestine, surrounds the pancreas and joins the hepatic and pancreatic ducts. The intestinal

epithelium is made up of villi and pits. The author said, "The movement of sustenances through the alimentary canal follows a precise digestive series that includes pre-hydration and softening, acidity, grinding, hydrolysis, emulsification, and ejection of the end products [6]. In birds that eat rough foods, the proventriculus is often slim-walled and glandular. The ventriculus is muscular, with thick, sturdy walls. The middle site links other parts. According to [7], the jejunum originates around the junction of the ascending duodenal loop and the cranial mesenteric-artery. The last part of the small intestine is considered to start at the vitelline (Meckel's) diverticulum and stop at the area of the recto-caecal junction [8]. In general, bird species are well described, but very little research has been conducted on bulbuls to date. As a result, the typical anatomical and histological features of bulbuls remain unclear. Therefore, the objective of this study was to provide a description of the differences between the morphometrical and histological features of the digestive systems of the two species.

Materials and Methods:

Ten birds (5 white-cheeked bulbuls and 5 Russian bulbuls) were obtained from bird shops at the Basra market. All birds were macroscopically healthy for both sexes. This study focused on the form, location, and histological makeup of the majority of the

digestive system. The histological study included digestive system samples that had been fixed in formalin for 48 hours, washed with tap water, pierced with increasing concentrations of 70% ethyl alcohol to 100%, and placed in xylene for clarification. The samples were immersed in melted paraffin wax, and the wax molds were cut after casting with a rotary microtome at a thickness of 6 micrometers. Specimen slices were visible through traditional staining [9].

Results:

Morphometric analysis:

Morphometric investigations revealed that the Russian bulbul had a longer alimentary canal, 27.5 ± 1.4 cm, compared to the white-eared bulbul, 22.7 ± 1.3 cm ($P \leq 0.005$). The mean length of the Russian bulbul's small intestine was 14.4 ± 0.9 cm, whereas the white-eared bulbul's was 12.1 ± 0.7 cm ($P \leq 0.005$). Russian bulbuls had a thicker The Russian bulbul has considerably larger goblet cell density (134.9 ± 10.35) than the white-eared bulbul (93.7 ± 8.4), with a ($P \leq 0.01$) table (1). These quantitative differences give morphometrical evidence for the Russian bulbul's higher level of mechanical and mucosal adaptation. Generally, the Russian bulbul has a greater degree of mechanical and mucosal adaptability.

Table 1. Show the morphometric analysis of the alimentary canal of the Bulbul, the Russian, and the White-eared Bulbul.

Parameter	White-eared Bulbul (Mean ± SD)	Russian Bulbul (Mean ± SD)	p-value
Total alimentary canal length (cm)	22.7 ± 1.3 cm	27.5 ± 1.4 cm	0.05**
Small intestine length (cm)	12.1 ± 0.7 cm	14.4 ± 0.9 cm	0.05**
Goblet cell density (cells/mm ²)	93.7 ± 8.4	134.9 ± 10.35	0.01*

* Significant at $p < 0.05$ ** highly significant at $p < 0.01$

The esophagus, proventriculus, ventriculus, small intestine (duodenum, jejunum, and ileum), large intestine (both caeca and rectum), and cloaca are all parts of the alimentary tract, according to morphological examination. Through the cloacal opening, the cloaca is exposed to the external environment. Both birds had a tubular, membrane, and muscular esophagus that extended from the oropharyngeal cavity to the proventriculus. The esophagus is split into three sections: the cervical, gizzard, and thoracic portions. The first section, the cervical, was found on the right side. The esophagus in both birds was an organ positioned on the right side of the neck and situated within the pharynx and the glandular stomach. The stomach is placed in the left-middle section of the abdomen. In both birds, the stomach was divided into two portions: the glandular stomach (proventriculus) and the muscular stomach (ventriculus or gizzard). The gizzard wall looked very thick, a fusiform line that emerged from the narrow end of the thoracic esophagus in the abdominal cavity. The isthmus separates this tube from the gizzard. The gizzard was covered with yellowish-green tissue, and the chyle formed an uneven pattern of longitudinal folds. On both sides of the gizzard, the small intestine of the Russian bulbul was longer than that of the white-cheeked bulbul. It was noted that the posterior portion of the abdomen was occupied by the small intestine, which consists of several folds on the right side of the abdominal cavity, as well as the gizzard. The ileum connects the large intestine caudally to the abdominal floor. In the two birds studied, the rectum appeared as a small tube at the end of the digestive tract. The anus follows the rectum, through which waste is expelled. In addition to the digestive tract, reproductive waste and urine enter the anus, which is divided into the rectum and the urinary rectum, respectively (figures 1 and 2).

Histological investigations of the gastrointestinal tract found that the esophagus is created by mucosa, submucosa, muscularis, and serosa, which are

identical in most birds. Stratified squamous epithelium with longitudinal folds makes up the mucosa. The loose connective tissue forms the lamina propria. A thin layer of muscularis mucosa, which is made up of loose connective tissue such as blood vessels, lymphatic vessels, and nerve fibers, separates this layer from the submucosa. Esophageal glands are simple, branching mucous glands that can be found throughout the membrane. The outer muscular layer consists of smooth muscle fibers and is bilayered, round, and longitudinal. It's a well-developed layer; compressions of the internal circular and external longitudinal arrangement muscles help push food backward via the esophagus. The outer layer consists of loose connective tissue that connects the organ to surrounding tissues; the above is similar in both birds (figures 3 and 4).

The glandular mucosa of the stomach, or proventriculus, resembles a finger; the mucosal epithelium is compact and densely packed with folds split by furrows. These folds are covered by simple columnar epithelium filled with a single oval nucleus at the bottom of each cell. Blood vessels, lymphocytes, and small tubular glands filled with columnar epithelial cells known as superficial glands opened at the bottom of each groove, which was embedded within the loose connective tissue (lamina propria) over which lay the epithelium of the mucosa. The Muscularis mucosa was invaginated beneath the lamina propria, toward the submucosa. The vast circular to conical mixture tubuloalveolar glands known as in-depth gastric glands, which occupied the bulk of the proventriculus wall and were divided from one another by connective tissue, and the loose connective tissue that made up the submucosa had a robust blood vessel supply. An inner circular muscle layer and an outside longitudinal layer make up the extrinsic muscle. Compared to the inner layer, the outer layer is thinner. The serosa is constructed from connective tissue, has many blood vessels and nerves, and has a

layer of squamous epithelium covering it on the outside (figures 5 and 6).

The mucosa lines most of the digestive tract, including the small intestine, and is composed of simple columnar epithelial cells. These cells cover the villi in each segment of the small intestine in both birds. Lieberkuhn crypts are found in the submucosa, which is deeper within the white-ear bulbul. The muscularis mucosae layer is relatively thin. The number of goblet cells varies in each segment of the intestine. The muscular layer is thinner in the white-ear bulbul. It is divided into two smooth muscle layers: the outer layer is thinner and more vascularized with Auerbach's plexuses, while

the inner layer is thicker and circular. The serosa membrane of both birds, which consists of a thin layer of loose connective tissue, is covered externally by simple squamous tissue (figures 7 and 8).

The large intestine of the white-ear bulbul is divided into four layers: mucous, submucosal, muscular, and serous. The submucosa is made up of lymphocyte clusters that form several nodules and is held together by connective tissue. The muscular layer is composed of two layers: a thin longitudinal layer and a thick circular muscular layer. This histological structure resembles that of the Russian bulbul (figures 9 and 10).

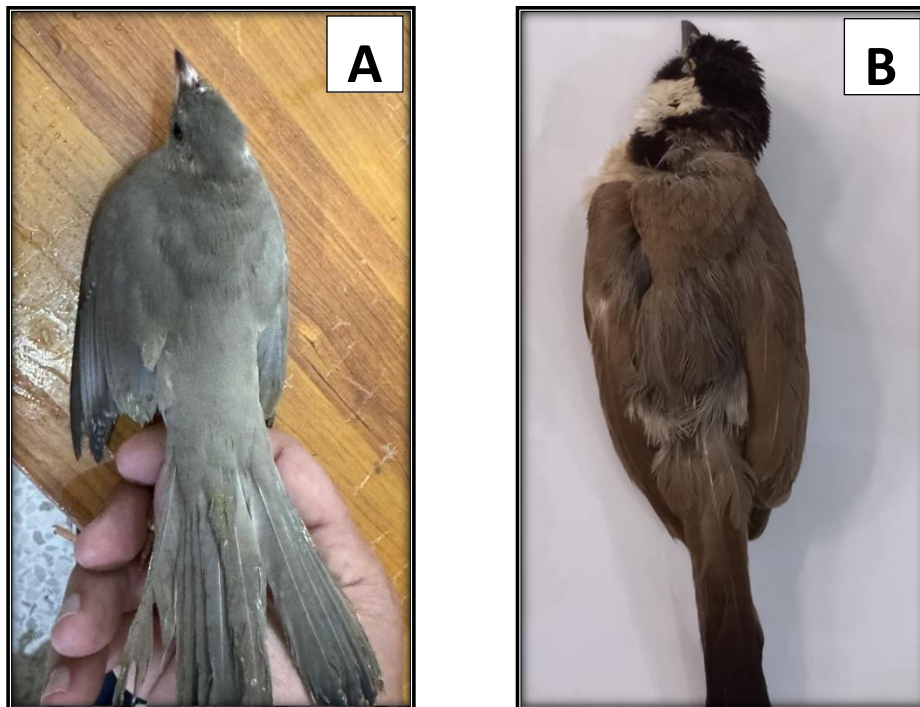


Figure 1: Photograph of the A Russian bulbul and B White-eared Bulbul.

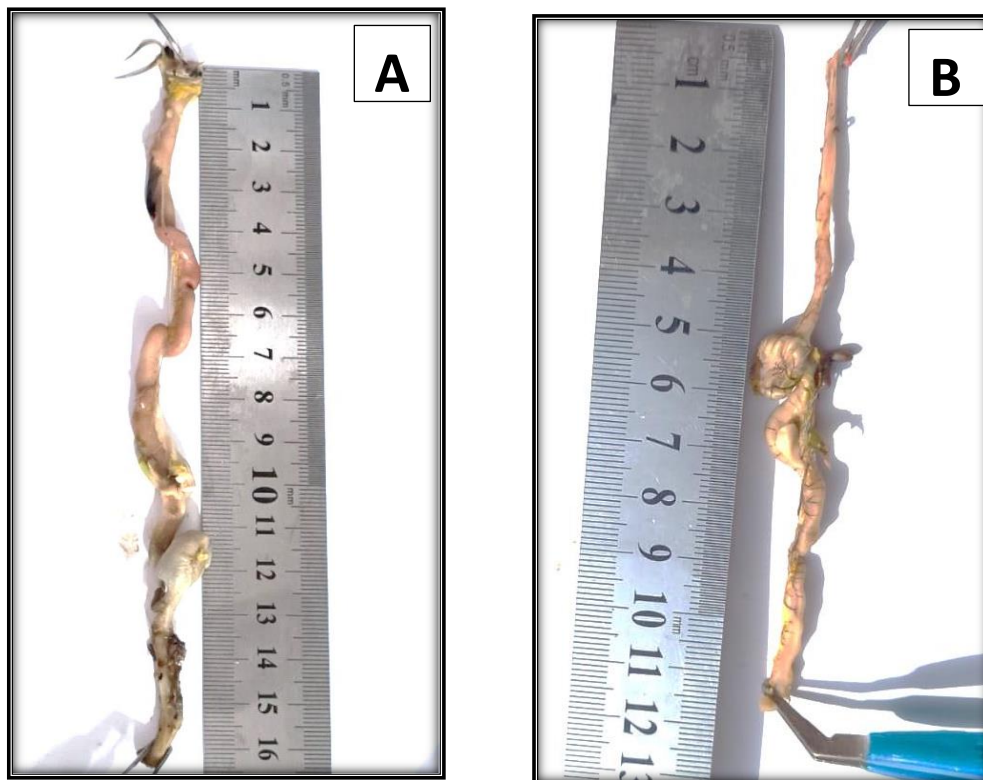


Figure 2: Photograph of the dissection of the alimentary tract of A Russian bulbul and B White-eared Bulbul.

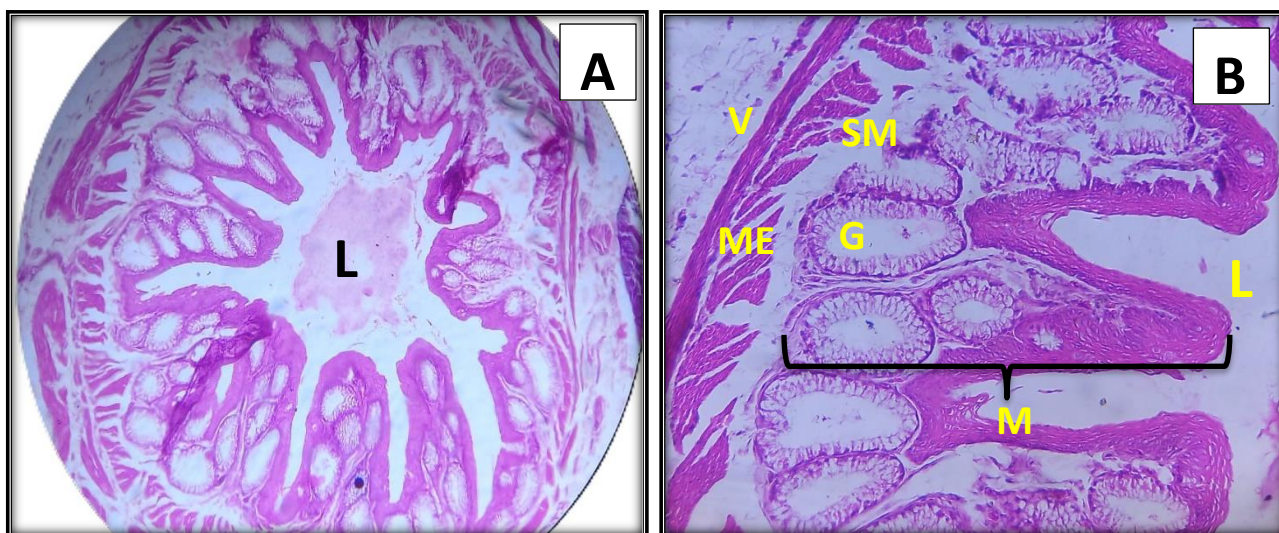


Figure 3: Cross-section in the esophagus of the Russian bulbul showed the lumen (L), mucosa (M), sub-mucosa(SM), muscularis externa (ME), esophageal gland (G) and adventitia (V). (A 4X), (B20X) H&E.

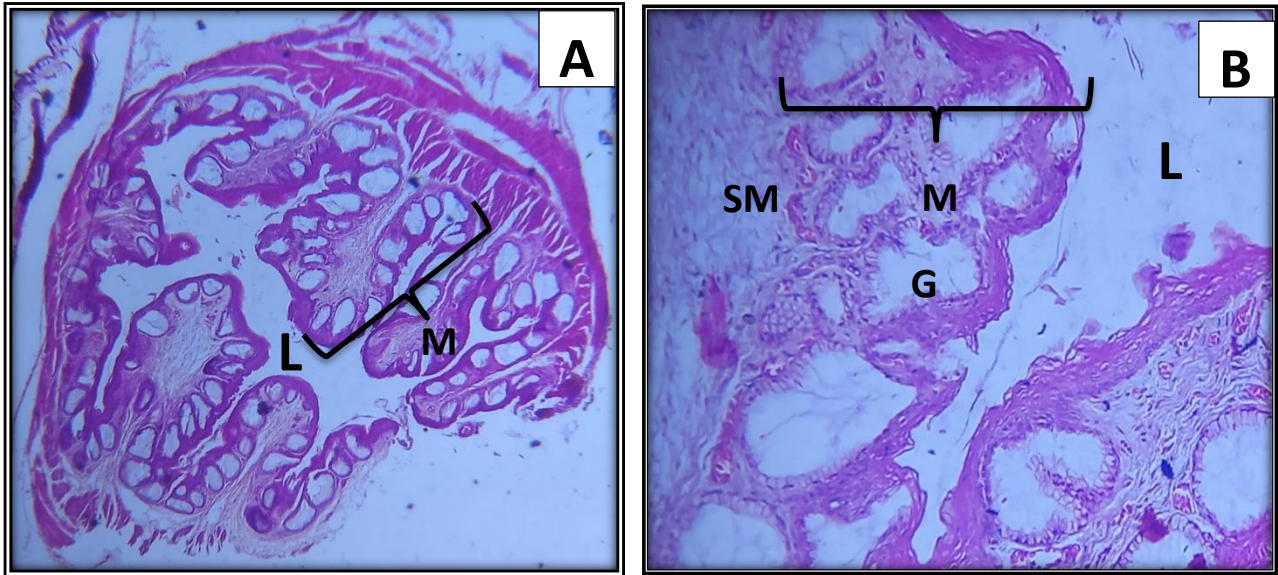


Figure 4: Cross-section in the esophagus of the white-eared bulbul showed the lumen (L), mucosa (M), sub-mucosa(SM), muscularis externa(ME), esophageal gland (G), and advetia (V). (A 4X), (B 20X) H&E.

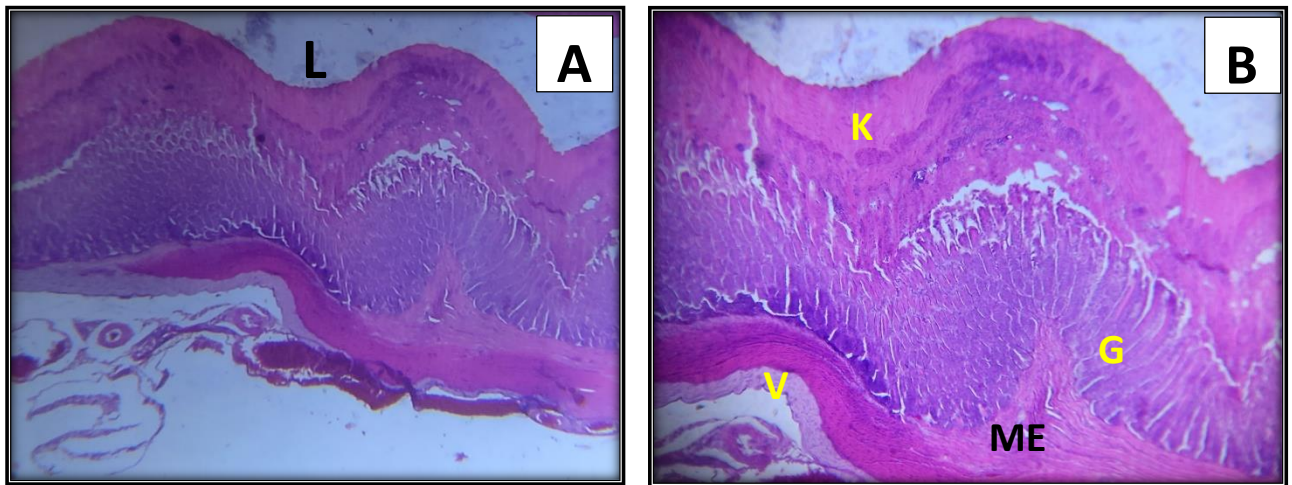


Figure 5: Photomicrograph of a transverse section of the ventriculus of the Russian bulbul showed the lumen (L), mucosa (M), sub-mucosa(SM), muscularis externa (ME), koilin layer (K), pyloric glands (G), and serosa (V). (A 4X), (B10X) H&E.

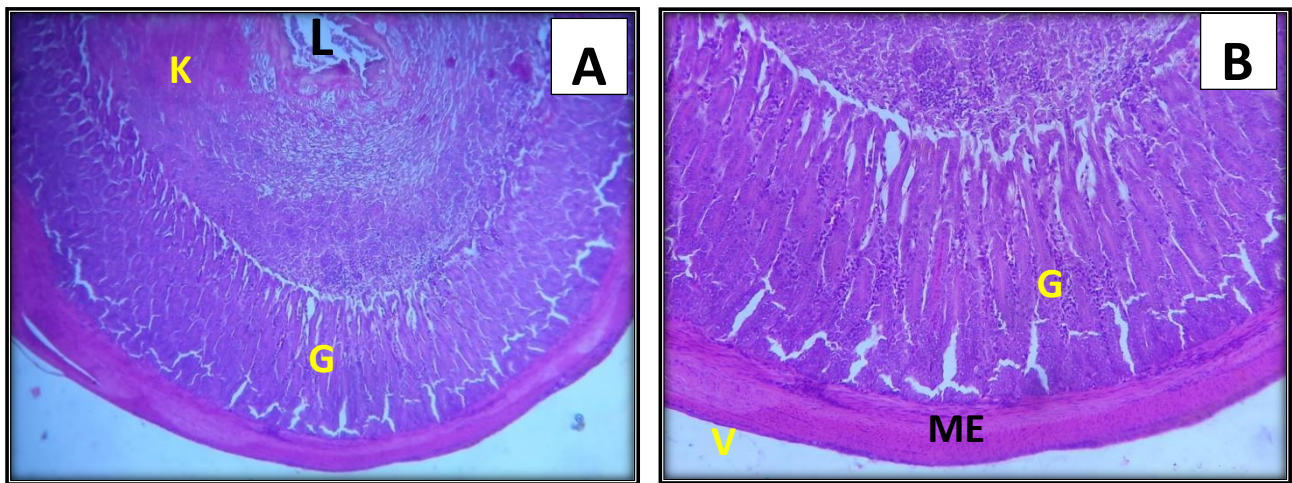


Figure 6: Photomicrograph of a transverse section of the ventriculus of the white-eared bulbul showed the lumen (L), mucosa (M), sub-mucosa(SM), muscularis externa(ME), koilin layer (K), pyloric glands (G), and serosa (V). (A 4X), (B10X) H&E

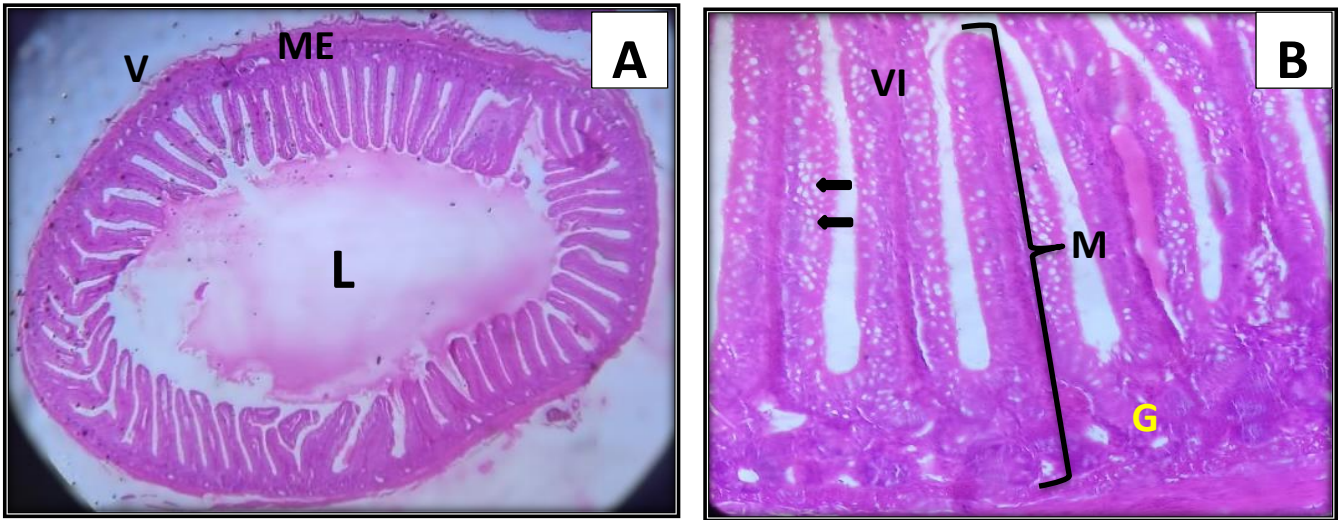


Figure 7: Cross-section in the small intestine of the Russian bulbul showed the lumen (L), mucosa (M), sub-mucosa(SM), muscularis externa(ME), advetia (V), goblet cell (arrow), crypts of Lieberkuhn (G), and villi (VI). (A 4X), (B20X) H&E.

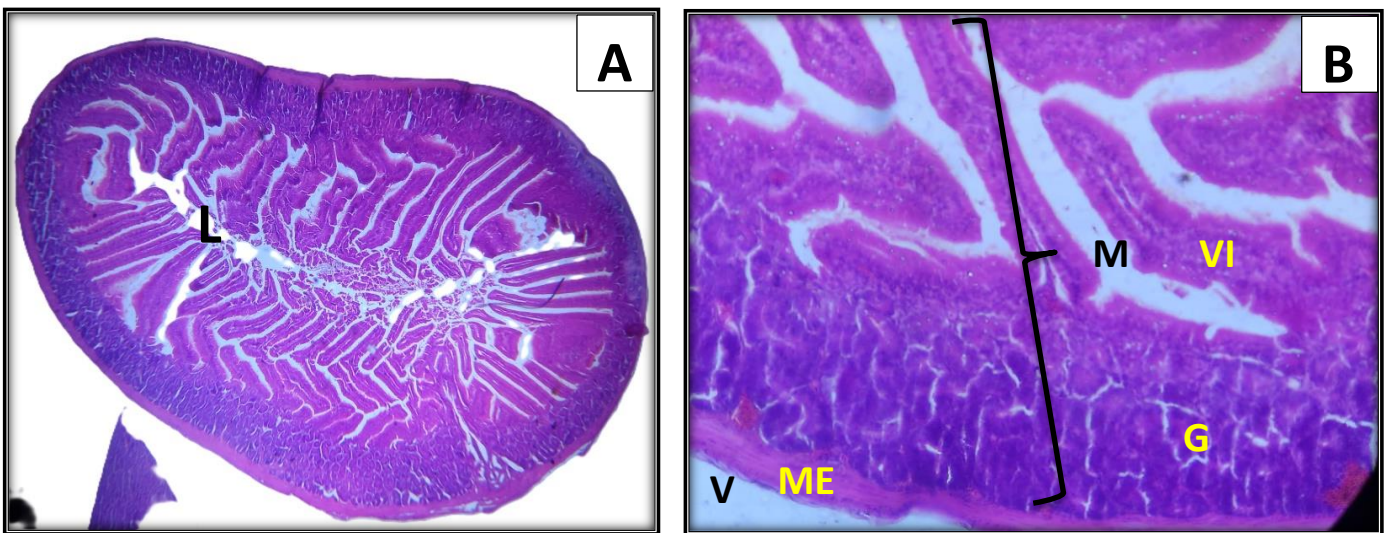


Figure 8: Cross-section in the small intestine of the white-eared bulbul showed the lumen (L), mucosa (M), sub-mucosa(SM), muscularis externa(ME), serosa (V), and crypt of lieberkuhn (G), villi (VI). (A 4X), (B 20X) H&E.

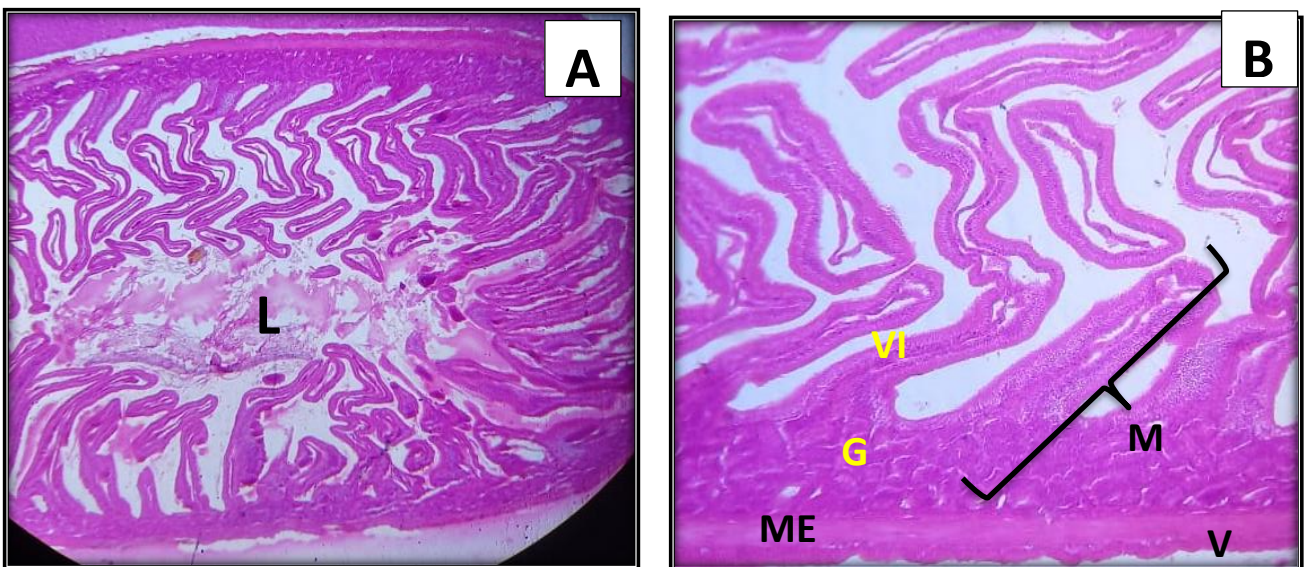


Figure 9: Cross-section in the large intestine of the Russian bulbul showed the lumen (L), mucosa (M), sub-mucosa (SM), muscularis externa (ME), crypts of Lieberkuhn (G), and serosa (V). (A 4X), (B20X) H&E

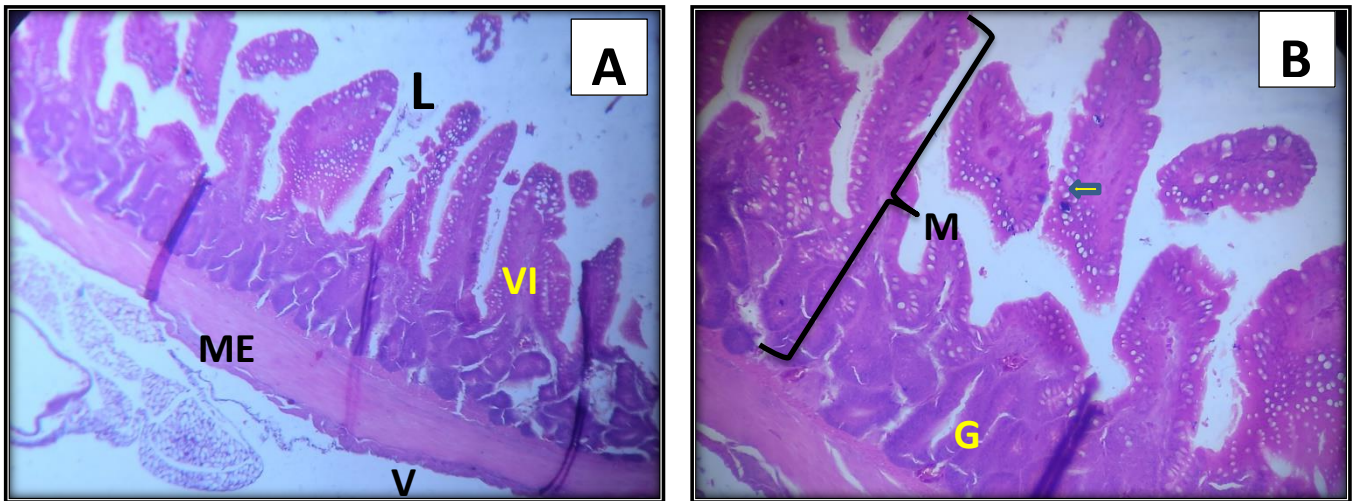


Figure 10: Cross-section in the large intestine of the white-eared bulbul showed the lumen (L), mucosa (M), sub-mucosa(SM), muscularis externa (ME), crypts of Lieberkuhn (G) and serosa (V), (A 10X), (B20X) H&E.

Discussion:

Anatomical analysis of the two birds' digestive tracts revealed that the esophagus was a lengthy tube with three main parts: the top section, which begins at the end of the mouth; the crop, a muscular-membranous sac; and the bottom half, which connects to the belly. These results are congruent with those of [10]. The majority of the bulbuls' stomach is made of smooth muscle that is situated between the gut and the esophagus. It is comprised of a muscular stomach and a glandular stomach. There are four semi-independent muscles that make up its wall: Two thick muscles, cranial ventral and cranial dorsal, and two thin, transparent muscles (cranial ventral and cranial dorsal), which are in charge of crushing ingested food. This observation is similar to that of [11]. According to these findings, the small intestine of the bulbul avian was separated into the duodenum, jejunum, and ileum. These findings are consistent with [12]. The rectum continues from the last section of the small intestine to the urinary system, where it forms a short and straight tube. This is consistent with [13]. Compared to the small intestine, the rectal villi are shorter, which is consistent with [14, 15]. Our results indicate that the

rectum is well developed and may provide a suitable environment for the digestion of fibrous meals; symbiotic bacteria are present, which is consistent with the results [16].

Histological examinations for this study revealed that the digestive tract wall of two birds divides into the same four fundamental layers as those of other birds: mucosa, submucosa, muscularis externa, and serous [17] reported similar findings. The esophagus wall is made up of a thin layer of simple squamous epithelium, called serosa. The muscularis is composed of two separate muscle layers: circular and longitudinal. This result is consistent with [14], the internal circular and external longitudinal muscles contract peristaltically, propelling food backward into the esophagus. Stratified squamous epithelium and mucous gland ducts along the surface of the mucosal folds; this finding is parallel to the observation [18]. The tubuloalveolar esophageal glands are located in the mucosa, and their presence can be considered another type of adaptation of the esophagus to the composition of the diet. Crop mucus glands can temporarily moisten seeds, making it easier for birds to eat tough, dry seeds.

Instead of being smooth, the folded mucosal surface is covered with numerous protrusions known as papillae. The thickest part of the ventricular wall, the ventricular glands, opens at the apex of these papillae and secretes mucus, hydrochloric acid, and pepsinogen into the gastric lumen through ducts. Since what was mentioned in [19] agrees with the finding of the current investigation, since the epithelium covering the surface of the ventricle was of the simple columnar type, the results of the current study confirm that the length of the small intestine in the Russian bulbul is longer than that of the Iraqi bulbul. Much research focuses on differences in goblet cell density across different parts of the gastrointestinal tract. Our result is similar to that reported that goblet cell density reflects increased secretion of glycoproteins in Russian bulbuls, in contrast to white-cheeked bulbuls, which were lower. It contains goblet cells with a spherical nucleus close to the base and secretory substances close to the surface, which secrete mucus to protect the intestinal epithelium. This is what he discovered [20]: these cells (goblet cells) are closely related to the nature of the avian's diet.

Conclusion:

The current investigation may indicate minor changes in the length of the digestive canal between the both birds, which might be ascribed to their size. The morphological disparities between the ventriculus in the two birds observed are the result of different feeding strategies. The white-eared bulbul's ventriculus differ somewhat from those of the Russian bulbul, which appear to be better developed histologically. Protruding from the mucosa of the small intestine are finger-like structures called villi containing bundles of muscle fibers originating from the muscularis mucosa, along with simple columnar epithelium and goblet cells. The Russian bulbul's goblet cells were more common throughout the small intestine than those of the white-cheeked bulbul, and their numbers

continuously grew as the bird's intestines neared the cloaca.

Ethics Statements:

This study was approved by the Institutional Review Board of Basrah University/ College of Veterinary Medicine under approval number [108/ 37/2025].

Acknowledgments:

The authors would like to thank all members of the Department of Anatomy and Histology, College of Veterinary Medicine, University of Basrah, for their continuous support in completing this article.

Author Contributions:

The idea, design, data collection, interpretation, and paper drafting were all done by the authors. The final version was read and approved by all writers.

Funding Statement:

No particular grant from a governmental, private, or nonprofit funding organization was obtained for this study.

Conflicts of Interest:

The authors declare no conflict of interest.

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